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The Role of the Impedivity in the Magnetotelluric Response of 1D and 2D Structures

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The influence of the resistivity dispersion on the magnetotelluric (MT) response is analyzed. MT uses the natural electromagnetic (EM) field to determine the electrical resistivity of the subsoil and retrieve the geometry of lithospheric structures, revealing the presence of bodies as metallic deposits, hydrocarbons reservoirs, geothermal fluids. The frequency range of the EM field used varies from 10-4 to 104 Hz. If the soil is polarizable, the dispersion of the resistivity, whose characteristic frequency interval is between 10-2 and 102 Hz, may affect MT responses.

Resistivity dispersion is a known phenomenology, which constitutes the basis of the Induced Polarization (IP) prospecting method. In the frequency domain (FD), the dispersion consists in a variation of the resistivity parameter as the frequency of the exciting current is changed. The dispersive resistivity, called impedivity, is a complex function of the frequency. At vanishing frequency, however, the impedivity is real and coincides with the classical resistivity parameter used in DC geoelectrical methods. A real asymptote is also approached as the frequency tends to infinity. The complex physical and chemical fluid-metal-rock interactions may produce induced polarization effects, which are related to the dispersion in rocks. This is manifested on the MT response, creating a distortion on the experimental curves. Disregarding the distortion effect may lead to misleading interpretation of the surveyed structures. We show the results from simulation of the MT responses, when dispersion is assumed to characterize the electrical properties of a region of the explored half-space. Initially, a 1D-layered earth is considered, with intermediate layer assumed to be dispersive. The influence of the dispersion amplitude on the shape of the MT responses is evaluated. The dispersion alters the shape of the curves in a way that, without any external constraints, may make the interpretation of the curves quite ambiguous. Successively, a 2D case is considered, consisting in a magma chamber at a depth of 1 km, buried into a soil. The synthetic responses were performed considering both the non-dispersive and the dispersive case and the differences of the modelled MT curves are compared. As for the 1D case, the dispersion alters the resistivity values, particularly at the boundary of the buried body, leading to an ambiguous interpretation. MT data alone are not sufficient to distinguish polarization effects or can induce to see dispersion where is not present. An approach to solve this problem consists of the combined interpretation of DC geoelectrical and MT data collected at the same site. Review of real cases is also shown.